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LOG AND TREE GRADING
AS A MEANS OF MEASURING QUALITY

A RECOMMENDED RESEARCH PROGRAM
PREPARED BY A WORKING GROUP FOR
THE NATIONAL LOG GRADE COMMITTEE

FOREST SERVICE - U.S. DEPARTMENT OF AGRICULTURE
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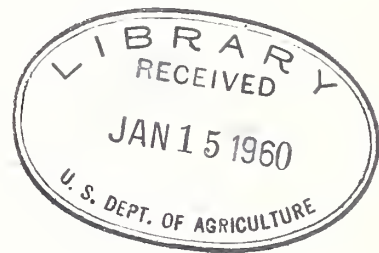1958

LOG AND TREE GRADING AS A MEANS OF MEASURING QUALITY

REPORT OF THE WORKING GROUP

As approved by

the National Log Grade Committee
at Madison, Wisconsin
May 1958

By

Carl A. Newport, Leader
C. R. Lockard
And
C. L. Vaughan

Forest Service
U. S. Department of Agriculture
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FOREWORD

Most foresters take pride in calling a spade a spade. Can
they be equally proud of calling quality "quality"? Certainly not!
When a forester says "That is quality," in reference to a certain
log, tree or forest, each listener has a different definition.
Early in 1957 the Chief of the Forest Service asked what could be
done to give foresters and timber users all the same definition of
timber quality. Because log and tree grades seemed to have the
greatest possibilities for helping them, a National Log Grade
Working Group was given the job of finding what could be done.
This Group has taken a swing around the nation and a long look in
libraries, and has come up with some definite conclusions and
recommendations.

CONCLUSIONS

I. <u>Objectives</u>.--Although foresters may differ on what timber quality is, they do agree wholeheartedly on what they want log and tree grades, as quality measures, to do for them. They have told the Working Group that grading systems should:

   1. Give dollar and cent value of products
   2. Show what logs or trees are better than others for making certain products
   3. Give volumes of various types of end-product
   4. Give a strong hint about the future of a growing tree in terms of end-products

II. <u>Performance standards</u>.--The Working Group also found out that foresters want to obtain these objectives with:

   1. A reasonable accuracy of dollar value per unit of volume.
   2. Differences between the unit value and/or end-product yields that are significant.
   3. Grade specifications that are easily understood and applied.
   4. A grading system which applies to as many similar uses, species, and regions as good performance will permit.

III. <u>Basic concepts</u>.--The Working Group had to complete a framework on which foresters can build adequate log and tree grading systems. This was done by adding the following basic concepts to the objectives and standards of performance given above:

   1. The end-products of a log or tree grade must have specific market values.
   2. The timber grading system must have a bottom in the form of minimum specifications.
   3. The specifications must include only certain timber characteristics in order to be clear and concise.
   4. The conversion system for which the performance is estimated must be specific and acceptable to the public and industry.
   5. The grading system must provide stable specifications. Needed changes through the years should be made only in what the system is required to do--its performance.

IV. <u>Adequacy of existing systems</u>.--What about the grading systems now in use? The Working Group tested the most common systems against the objectives, standards of performance, and basic concepts. Few systems adequately passed the test. What can be done about the others? They can be raised to standard by the action recommended by the Working Group.

RECOMMENDATIONS

1. Five field projects should be established to carry out needed research on log and tree grading systems for the following groups of commercially important species:

   > Ponderosa pine and certain associated softwoods
   > Douglas-fir and certain associated softwoods
   > Southern pine and certain associated softwoods
   > Eastern white pine and certain associated softwoods
   > Hardwoods, both eastern and western

2. The five field projects should result in the acceptance by the Forest Service of existing, new, or revised systems for:

   a. Grading logs in the standing tree.

   b. Grading logs after they are cut.

   c. Grading trees.

3. A pioneering project should be established to develop basic timber quality information and to study the possibilities of grading trees on some basis irrespective of special end-products.

4. The Working Group recommends that these six projects be coordinated in the Washington Office by the Branch of Research. These projects should include all the present work now being carried out in grading research in order to gain efficiency, economy and uniformity.

5. The six projects should be able to give definite and usable results in 3 years or less if a total annual appropriation of $400,000 is made available.

LOG AND TREE GRADING AS A MEANS OF MEASURING QUALITY

Report of the Working Group

INTRODUCTION

In May of 1957 the Chief of the Forest Service and his staff held a conference at Madison, Wisconsin to discuss timber quality. After this conference he asked the National Log Grade Committee to advise him regarding an action program in log and tree grading research as a solution to part of the timber quality problem. This committee promptly acted.

At its July 1957 meeting in Quincy, California, it recommended that "a strenuous immediate effort be made to inaugurate such a coordinated national effort" and that action proceed by the establishment of a permanently assigned Task Force set up to do certain specific jobs. The recommended permanent Task Force was not set up for various reasons but instead a temporary working group was assigned to carry out more limited objectives. This working group consisted of Carl A. Newport, Leader, C. L. Vaughan, and C. R. Lockard. The objectives of the working group's effort outlined in the working plan submitted to the Chief's Office by the Leader on August 25, 1957, were as follows and were to be attained by early 1958.

1. To formulate a clear statement of the problem of measuring timber quality and to set up uniform objectives for research in log and tree grading.

2. To establish basic concepts and standards of performance to be used in developing, testing, and applying any system for measuring timber quality.

3. To suggest uniform research techniques to be used in the analysis of timber quality data.

4. To recommend a program for Service-wide action in log and tree grading research which is realistic in terms of the magnitude of the problem, and the difficulty of its solution, and the availability of funds and personnel.

This report is the Working Group's answer to these objectives. We first gathered information in a search of the literature and of unpublished reports. The Group then visited each experiment station and regional office territory and held meetings with the regional log grade committees. These meetings were supplemented by other meetings in each area, particularly where any special work in log or tree grading was being done. We recognized that this report is "in-service" in character, but that the problem and its solution were not. Therefore, every opportunity was taken in each region to obtain pertinent information regarding log and tree grading systems and studies involving state, private, and other federal agencies.

We believe that this report is the proper beginning for a program of research to establish adequate timber quality measures. The report is intended to provide the framework within which the development, testing, and application of grading systems must be carried on. Those who have worked with timber grading for any length of time will recognize that this report simply presents in one place and in an organized manner the things which many foresters have been saying and doing for many years.

In preparing this report, the Working Group considered all types of quality grading and all of the many use-classes for wood material.

Although log and tree grading systems in a more conventional form were given first consideration, unusual methods (Toole, McCormack, Grosenbaugh) were discussed in some detail. We have attempted to integrate all of the current and future research activity dealing with grading systems and other timber quality measures into one unified program.

We will present in sweeping fashion the development and application of log and tree grading systems in the United States. This we will follow with a presentation of the major objectives which foresters feel they wish to attain through the use of log or tree grading systems. We found it necessary to include standards of performance with these objectives. These standards indicate how well and how easily the forester wishes to attain the objectives. Up to this point we were dealing with facts collected in the field. Now the Working Group had to do some thinking on its own. We came up with what will be called basic concepts. These, we have agreed, are necessary to the development and application of any log or tree grading system. At this point we have included a section on the research techniques needed. Having done this, it was possible to briefly test the existing grading systems for their adequacy in attaining the objectives accurately and efficiently, in a manner in keeping with the basic concepts. The report concludes, and we hope action starts, with a recommended program.

Certain definitions and distinctions had to be made before the members of the Working Group could converse. First of all, a distinction was made between classifying and grading. Classifying refers to the placement of logs or trees in groups on the basis of whether or not they can be physically converted into a given type of end-product. The minimum specifications for a use-class will be determined at some point above the least physically usable log or tree. Such minimums have to be established on the basis of economics and utilization in a somewhat arbitrary manner. Grading refers to the placement of logs or trees into quality groups within a use classification. The poorest grade in a use-class must meet the minimum specifications for the use-class.

End-product was another term which gave us trouble. In this report "end-product" will refer to wood products at any stage of product conversion at which the wood material may be transferred or exchanged from one mill to another or otherwise reaches a form that is generally recognized on the market. Under this definition, softwood yard lumber can be an end-product

for the purposes of developing a set of log grade specifications. In
this same example, softwood logs are the end-product used for the develop-
ment of tree grading systems.

Other terms which we needed were as follows:

Log -- the term log in this report will be used in a broad sense
to mean a segment of the bole of the tree. Log as thus
defined may be as actually cut or may be a designated
portion of a standing tree. The term log includes poles,
piling, bolts for various uses, and other piece products.

Log grading system -- the set of specifications used to segregate
a given lot of cut logs into two or more log grades.

Tree-log grading system -- the set of specifications used to
segregate designated portions of trees (uncut logs) into
two or more grades.

Tree grading system -- the set of specifications used to segregate
a given lot of trees into two or more tree grades.

Log or tree grade -- refers to one of the two or more groups of
trees or logs in a system.

Log or tree grade specifications -- those terms or measures used
to describe the characteristics of the type of logs or
trees that are to be placed in a given grade.

Log or tree grade performance -- those graphs, tables, or other
numbers or words used to indicate, and to set limits on,
what the logs or trees in a given grade will produce in
terms of end-products or value. As will be shown later
performance also includes the idea of reliability as
determined by and expressed in statistical terms.

Because the Working Group was to deal with log and tree grading
systems as a method for measuring quality, we had to define quality.
Quality was defined as that property or group of properties exhibited
by a log or tree which make it physically suitable for conversion into
"end-products" for a given use. High, medium, and low quality then re-
fers to those logs and trees which have combinations of those properties
such that they can be converted into "end-products" having the most, the
average, or the least advantage, respectively, in the broad use-class of
that particular product.

Please bear in mind as you read this report that the Working Group
was not asked to justify the need for measures of timber quality. We were
directed to recommend rules for the game and an organization for the team.

I. THE DEVELOPMENT OF LOG AND TREE GRADES AND THEIR APPLICATION

A. DEVELOPMENT

1. General

Quality determinations have been made in the United States since the very first settlers began using forest products. The frontiersman had to visualize in the standing tree what types of end-products could be manufactured. His methods of quality distinction were probably rather crude according to modern ideas and existed only in his mind as an experienced timber user.

Prior to 1930, there was no generally accepted concept of timber quality and relatively few research-based systems for measuring it. In only a few areas, advanced standards had been developed. From 1930 on, interest in the field mounted, particularly during the war years. The last few years a great many studies have been made for various purposes. The majority of the research-based developments have been directed toward lumber as an end use.

Several studies have been made recently for the development of tree grading systems. These have generally been based upon some already-developed log grading system. The Working Group found that the methods used in the development of grading systems were more pertinent to this report than an historical summary of the development of specific systems.

2. Methods

This complete study of grading systems all over the United States has revealed to the Working Group that it is possible to classify the methods used in grade development into three groups. Keep in mind that any given grading system may have been developed by one or a combination of these methods.

a. Judgment grading systems

Judgment was the basis of the development of the log grading systems in use by the grading bureaus on the West Coast. The development starts with a statement of what type of product and the minimum amount of it required to be produced from a given log or tree. Actually, in the terminology of this report, this is a statement of performance. The grader must use his judgment in estimating whether a log will produce the stipulated amounts of key items. In this method of development the specifications for a grade are the same as its performance. However, as time passes, outward indicators or characteristics are added to the specifications in order to help less experienced men in the application of the grading system.

b. Arbitrary grading systems

The first step in the development of an arbitrary grading system
is the writing of the specifications. These are set down by experienced
woods and mill men and are based upon the more obvious visible log
characteristics, such as size, clearness, knot size and distribution.
These men recognize that there is some relationship between these
characteristics and product quality, but the relationship is not
established from direct study. Generally the average product yield of
the logs or trees within a grade in these systems is determined after
the specifications are written. However, it is possible that the per-
formance may never be determined.

c. Analytical grading systems

Analytical development of a grading system starts with a thorough
study of the relationship between log characteristics and product or
value yields. After such study reveals which log characteristics are
the most important in controlling product or value yields, it is then
possible to write sets of specifications which group the logs by similar
characteristics. The product or value yields for each group or grade
within a system is then determined and presented as the performance for
that grade. The Hardwood Log Grades for Standard Lumber as developed by
the Forest Products Laboratory are of this type.

Complete information is not available on the methods used for
developing every log and tree grade system on record. Probably most of
them have been developed by one of the first two methods. Certainly the
West Coast Bureau Grades are known to be judgment rules. Individual
company grades are generally arbitrary. Only a few have been developed
by the analytical method. The Forest Service Hardwood Log Grades for
Standard Lumber Logs and the Interim Southern Pine Grades are examples
of this method. The balance of the log grading systems which are in
use today were probably developed by the arbitrary method or by a com-
bination of the arbitrary and analytical methods.

B. CURRENT APPLICATIONS OF GRADING SYSTEMS

The Working Group investigated the current applications being made
of log and tree grading systems in each region of the United States. Our
goal was to record all of the applications of each grading system.

However, because of time limitations, adequate information was
obtained for the various Forest Service functions but only limited data
for outside applications. Hence, only those applications that are wide-
spread or are made by public agencies can be discussed in this report.
Likewise the comprehensive but partial check lists of log and tree grading
systems found in the Appendix includes only a few of the systems used by
single firms or individuals.

In the following discussion, the current applications of log and tree grading systems are broken down on an organizational and functional basis. For complete coverage, a log or tree grading system is repeated under each organization and function in which it applied.

1. Forest Service applications

The three main Forest Service functions in which quality measures are used or needed are National Forest Administration, State and Private Forestry, and Research. We discovered that all of the Forest Service applications of grading systems occurred under these three functions.

a. National Forest Administration

(1) Grading is important in sales and appraisals.

Undoubtedly the appraisal and the administration of timber sales are the most important of all the activities in which log or tree grading is used. The inadequacy or lack of grading systems is most easily recognized in these activities. The following is a brief summary of the applications being made by NFA in sales and appraisals by regions.

Region 1.-- The Intermountain Forest Survey Grading System is used in appraisals to a limited extent in Region 1. It is currently being tested in mill-scale studies for application to white pine and white fir. The Region 6 Ponderosa Pine Log Grading System is now or will, in a very short time, be used in appraisals in this region. Although I. V. Anderson has written specifications for tree grades in Region 1, there is no indication that his are being used.

Region 2.-- Foresters in this region are not using any log or tree grading system. A recent study of the Rocky Mountain Station checked into the adequacy of a set of trial log grades for Engelmann Spruce. The results indicated that diameter was as good an indicator of value as the trial system. Interest is keen in this region for the use of log or tree grades. Several studies have been made in ponderosa pine and in lodgepole pine in order to test some of the existing log grading systems of other regions. So far none have been accepted for use in appraisals.

Region 3.-- The Region 6 Ponderosa Pine Log Grading System is being used in all the appraisals of large sales of this species in Region 3. Apparently the appraisers are rather well satisfied with the results being obtained. The staff has expressed a need for a system of log grades to facilitate appraisal in Douglas-fir, spruce and white fir. At present these species are only a small portion of the total cut.

Region 4.-- This region has been using the Region 6 Ponderosa Pine Log Grading System in appraisals since 1955. There are no other log or tree grades in use now.

Region 5.-- This region uses log grades in appraisals extensively. At the time of this study, they had in use the following 4 grading systems: Eastside Pine Log Grades, the Westside Pine Log Grades, the Wildwood Douglas-fir Log Grades, and the Dolbeer and Carson Redwood Log Grades. The regional forester's staff has recently made an appraisal base study using an arbitrary set of log grades for white fir. Plans are made to test them in application before using them. This region is also reconsidering the adequacy of their Wildwood Douglas-fir grades. Some application is also being made of the Northern California Grading Bureau Log Grades for Douglas-fir. Each of these log grade systems is being applied in the standing tree to all of the merchantable portion. In addition to determining the average selling price of lumber for the appraisal, this region uses the yield data for the log grades and diameters to indicate in the sale prospectus the relative amount of end-products expected.

Region 6.-- Region 6 also uses log grades extensively. The following log grading systems are in use for the appraisal of standing timber:

> Region 6 Ponderosa Pine Log Grades
> Columbia River and Puget Sound Bureau Douglas-fir Grades
> Columbia River and Puget Sound Bureau Sitka Spruce Grades
> Columbia River and Puget Sound Bureau Hemlock Grades
> Columbia River and Puget Sound Bureau Cedar Grades
> Trial Log Grades for Associated Species

The Region 6 Ponderosa Pine Log Grades are used in timber appraisal in the following manner. The cruiser grades the logs in 16-foot lengths in the standing trees on every fifth cruise plot or on a 1/25th acre plot in the center of every cruise plot. He tabulates the volume by 3-inch log diameter classes for each log grade. A table of "Sales Realization Expectancies" is available to help him calculate the total value of logs based on shipping tally volume. The table mentioned is made up in the Regional Office each year by using the original percent lumber grade recoveries and recent lumber price data. The appraiser computes the average selling price, shipping tally, from the cruise data and this table. This price is then adjusted by a weighted over-run. The weighted over-run is computed from a table of over-run by diameter class. This procedure is an illustration of a method of applying a log grading system in appraisal. The Bureau Log Grades and the Trial Log Grades for Associated Species are applied in a similar manner in this region.

The history of the Region 6 Ponderosa Pine Log Grades is somewhat obscure. Apparently the grade specifications were written in a rather arbitrary manner prior to or shortly after a series of mill studies was begun. These mill studies were made at 12 mills and covered over 10,000 logs. Although segregation of logs into value groups was a declared objective in the development, there is no indication that a test was made to determine the reliability with which these grades did this.

Region 7.-- Region 7 appraisers measure the quality on small sales (less than $2,000) by comparing the stand to be sold with another recently sold in the same area. The current policy is that on all other sales each log in sample trees will be graded by the Forest Service Standard Hardwood Grades. In this procedure no compensation for hidden defects is made because it is believed the effect of these is unimportant in this area. Softwoods are not graded. This Region has held numerous training sessions for its personnel.

Region 8.-- Appraisals in Southern Pine are based upon a classification of trees into the categories of poor, good, and excellent. These categories are determined from the grade of the butt log under the Interim Southern Pine grading rules. The Regional Office has developed an index of value for these three tree grades. In those Southern Pine areas where there are poles, the regular pole specifications of the ASA are used.

The Forest Service Hardwood Log Grades for Standard Lumber are used only indirectly for appraisal. The Regional Office has made studies to determine the value of hardwood logs in the various grades and sizes and of the cost of conversion. Using these the appraiser can set a limit of merchantability on the basis of the marginal value of the logs. He can also include in the sales prospectus a statement of the volume of timber which is in Hardwood Log Grade No. 3 and better. The timber management staff claims that they do not use the hardwood log grades in the actual appraisals because of two difficulties: (1) the cruiser cannot see the end defects, and (2) he cannot see surface defects above the butt log in the tree. In the Appalachians, Campbell's Hardwood Tree Grading System is applied in appraisals. This system is a tree grade based on the grade of the butt log under a modification of the Hardwood Log Grade System. Region 8 foresters point out that the tree grades are not entirely satisfactory because of the need to determine merchantability. For example, the grade assigned to a tree on the basis of the grade of its butt log does not indicate whether there are any unmerchantable logs in the upper portion of the tree.

Region 9.-- Most of the timber appraisers in the North Central Region use the Phelps Study. This study developed the yields and values of trees by DBH classes. We need not discuss the simple details of the application of these study results to appraisals of other timber.

Another method of timber appraisal being used in this region is one based on stand quality classes as determined on the Chequamegon National Forest. The application of this method involves the determination of the quality class of the stand to be appraised. There are tables available which relate this stand quality to an estimated portion of volume in each log grade for the Hardwood Log Grading System. The appraiser can determine the lumber grade yields of a stand using the lumber grade performance tables for the Standard Hardwood Grades. Only a limited application of this procedure has been made.

The Regional Office has chosen not to grade logs in the standing tree even though the Hardwood Grades are accepted as standard by the Forest Service. This, they say, is necessary because the grades require that the end defects of the logs be seen by the grader. There are no other hardwood log grading systems and no softwood grading systems used in Region 9 for appraisal purposes.

Region 10.-- The Puget Sound Bureau Log Grades for Douglas-fir, Sitka spruce, hemlock, and cedar are used in Alaska in timber appraisals. Apparently appraisers have used log prices for these grades in their appraisals in the past. The first mill scale study by the Forest Service in Alaska was made recently to determine lumber selling value which will replace log value in appraisals.

(2) Grading helps greatly in silviculture and management

Regardless of the type of end-product the forester contemplates from his forest he will have as an important objective of management the production of trees which have combinations of physical properties such that they can be easily converted into the most desirable end-products in the use-class he contemplates. Or, in the terminology of this report, he will have as an objective the production of high quality. To do this he must have some measure of quality. Such a measure can be used effectively in marking, thinning, pruning, and other management practices. Only two of the 10 Forest Service regions use grading systems in their management operations. Region 7 uses some log grades in establishing merchantability limits in the marking of timber for sale. Region 8 uses the Hardwood Log Grades in a similar manner. Almost all of the regions strongly expressed a need for tree grading systems which can be used in silviculture and management operations. The strongest expression of need came from foresters in eastern United States where many second-growth forests are now reaching merchantability. The forester is without any adequate tool for decision-making at this critical time.

b. State and Private Forestry--Cooperative Forest Management

The CFM forester needs timber quality measures as he assists the private forest land owners in growing and marketing forest products. The types of grading systems needed are very much the same as those needed by the foresters in National Forest Administration. However, there is an additional need for log grading systems to apply to logs or bolts being sold by small forest owners to timber products buyers.

Regions 1, 2, 3, 4, 5, and 6. In the western regions very little use of log or tree grades is made in Cooperative Forest Management work. The CFM foresters do use the West Coast Bureau grades in assisting private land owners in marketing forest products in Washington and Oregon.

Region 7. Foresters in the Division of State and Private Forestry are using the Standard Hardwood Log Grades and the Northeastern Timber Salvage Administration log grading systems (NETSA) in their contacts with the larger forest land owners. They have not yet had much success in selling the grading idea to these owners.

The 150 Service foresters in this region have been informed about standard log grading procedures and use them occasionally. Because of lack of general understanding and of improved application methods and data, they have not been able to use these procedures as much as their importance warrants. They have in the past participated in and expect in the future to participate in training programs on this subject among themselves and with industrial foresters.

Region 8. In this region the Interim Log Grades for Southern Pine and the Hardwood Log Grades for Standard Lumber are used by the CFM foresters. Details as to the extent of their use are not known.

Region 9. Specific log or tree grading systems as defined in this report are not used by the CFM foresters in this region. However, some local log grading systems based on use-classes are applied. The Woodland Analysis System has been universally adopted by the Region 9 state foresters and all farm foresters. Currently, 86 of them use this analysis as the basis of their management plans on operable woodlands. The system divides the trees in a stand into 4 groups called good growing stock, operating stock, harvest stock, and cull stock. The characteristics for the classification of the trees include many physical factors which we know are important in determining the type and quality of end-product which the trees can produce now and at a later time.

c. Research finds many useful applications of grading

Forest researchers may and do find log and tree grading systems important tools in many phases of their activities. One series of activities is that involved in developing and testing systems. The working group, however, is concerned with the use of fully or partially developed application procedures. Forest products and forest utilization, forest economics, and forest management are the research divisions which have been primarily concerned.

(1) Forest Products and Forest Utilization Research

The Forest Products Laboratory and the forest utilization research divisions at the various stations are, of course, involved in the development and testing of grading systems. Other studies where grades have been a prime factor have included those on sawing techniques, tree bucking, and comparative yields of products of various kinds. Most of the studies have been in the field of hardwood utilization with the Forest Service Standard Hardwood Grades used as control. You may obtain some indication of the amount of work done to date by reference to the table in the Appendix on the number of grade yield studies by species.

(2) Forest Economics--Survey

For the most part in the Survey, the use of grading system is confined to the inventory phase; no general use of grades in drain work has been made. In recent years, special utilization studies have been made in which the grades as used by the inventory were applied to determine the makeup of the timber cut. No general application of these data to inventory information, however, has been made since the studies were presumably quite sketchy.

Inventory applications of log and tree grades are discussed on the basis of Experiment Station areas rather than Regional Office areas.

Pacific Northwest.-- The Forest Survey uses the Region 6 Ponderosa Pine log grading system on ponderosa, sugar, and white pine. All of the merchantable bole of the sample trees is graded although Manual instructions require only the first two 16-foot logs to be graded. The Puget Sound Bureau Log Grade System for Douglas-fir is the only other log grading system used by Forest Survey in the Pacific Northwest. The Manual specifies that the first two 32-foot logs should be graded by this system. However, in actual practice all of the bole is being graded.

No accuracy standards have been set for the quality estimates. Quality is not considered in determining merchantability class. Up to the present time the Survey has not considered that the system gives adequate quality information on a county basis. However, what the Survey is obtaining may be adequate for an area as large as one-half of a state.

California.-- The Forest Survey in California uses the Eastside and the Westside Pine log grading systems, the Wildwood log grades for Douglas-fir, and the Dolbeer and Carson log grades for redwood. For various reasons Forest Survey does not feel that the quality information obtained by the application of these log grading systems is satisfactory.

Intermountain.-- The Intermountain Experiment Station is in charge of Forest Survey for Regions 1, 2, 3, and 4 of the Forest Service. The Intermountain Forest Survey Log Grading System, as developed by I. V. Anderson, is applied to all the species in these regions with the exception of ponderosa pine in Region 4. This latter species is covered by the Region 6 pine log grade system. Foresters in this Rocky Mountain area have found only a few Grade 1 and 2 logs under the Survey System.

Lake States.-- The Forest Survey grades the hardwoods in the Lake States by the Forest Service Hardwood Log Grades for Standard Lumber. For tie and timber logs only the minimum specifications are used. In the State of Iowa there is also a local-use category being applied.

The grades are applied to each log in the standing sample trees. To compensate for any undergrading that may occur, because the logs cruised are all 16 feet long, a 12 or 14 foot indicator section is used to determine the grade of the 16 foot section. No compensation is made for hidden end defect. The Lake States Station also uses the Northern Hemlock and Hardwood Manufacturing Association grades for aspen and softwood logs.

Central States.-- The Central States Survey also uses the FPL standard log grades in the hardwoods. The only softwood log grading system used in the Central States territory is the Interim Log Grades for Southern Pine.

Southern.-- The Hardwood Log Grades are being used on the first two logs of the sample trees without end defect compensation. The Interim log grades for Southern Pine are also being used on the first two logs of the sample trees in the southern pine species.

Northeastern.-- The Forest Survey in the Northeast uses the Forest Service Standard Hardwood Log Grades (Factory and Construction) as well as a local-use grade without compensation for hidden defects on hardwoods. For white pine the NETSA log grades are used. These are applied to each log in the standing sample trees. Spruce, hemlock, and fir are under the OPA log grading rules. The Northeastern Station grades its limited volume of southern yellow pine with an adaptation of the Crossett Southern Pine Log Grading System.

Southeastern.-- The Forest Survey in the Southeast uses the Hardwood Log Grades for Standard Lumber with an added grade for hardwood tie and timber logs. They also use the Interim Log Grades for Southern Pine for grading the yellow pines, cypress, and the small volumes of white pine, hemlock, spruce and fir. Southern foresters express concern over the problem which arises out of the use of these log grading systems which have specific end-products in mind. Such systems do not permit them to classify the entire bole of some trees, nor to classify certain trees which are not suitable for production into these specified end-products. They ask for a grading system for trees without reference to the end-product.

(3) Forest Economics--Marketing

Log and tree grading systems are important tools in timber marketing activities. Marketing research at several of the experiment stations has assisted in testing and developing adequate grading systems. Other marketing research has been limited to studies of marketing of lumber, pulp, and paper as end-products because of the lack of adequate log or tree grading systems. There has been some research done which applies grading and this will be mentioned briefly here.

Pacific Northwest.-- In this area prices have been reported by the several Bureau log grading systems for several years. However, the specifications for these log grades are such that the economist refuses or hesitates to base research upon them.

(4) Forest Management Research

The Forest Management Research divisions at all of the experiment stations expressed a need for quality measures, particularly tree grades. Almost all of the research foresters were expected to investigate the growth of "high quality" timber for various uses or for some specific use. These foresters have very exacting requirements for the grading systems they will use. Consequently they make little use of the existing grading systems.

Pacific Northwest.-- None of the existing log grading systems in this region have been used in forest management research studies. A study of product yields from a second-growth ponderosa pine stand was recently completed. The need for a quality measure in this study led the researcher to make two tree grades. These were simply close-grown and open-grown trees.

California, Intermountain, and Rocky Mountain.-- The Working Group did not record any current use by forest management research of the existing log or tree grading systems. However, the researchers at each of these stations did express strong need for a usable grading system.

Lake States.-- A recent optimum stocking study in this region applied the OPA log grading system as a quality measure. The FPL Hardwood Log Grading System is being used in management compartment studies to measure the influence of management on the quality of yields. This Station also reported two thinning studies in progress in which the lack of a suitable grading system will limit the effectiveness of the studies.

Central.-- Several forest management studies in the Central States area involve the use of log grades or other quality measures. At Carbondale, Illinois, two studies are in progress. One of these is a study in which stand structure is being analyzed. The trees which are being harvested from several stand structure plots and certain of the trees which are being left are diagrammed from stump to merchantable top. Another study at Carbondale in management compartments calls for diagramming of the trees which are being cut. These diagrams serve to overcome the difficulty which would arise if a log grading system being used were changed before the compartment study was completed. At Athens, Ohio, log grades are being used to keep account of the character of the harvests that are made. At Berea, Kentucky another study is being made of pine stocking. In this study the poles are being graded by the ASA grading rules.

Two studies in genetics that relate to the problem of quality measurement were reported by foresters in this area. One of these is a study of fiber length and its relation to environment and inherited characteristics

in cottonwood. The other study is a seed source study in yellow poplar, loblolly pine, and red cedar. In this latter study researchers hope to be able to establish some relationship between seed source and quality. At this time it has not progressed to the point where quality measurements are needed, but it should not be too long before this point is reached.

Southern.-- Two management studies in the Southern Station territory are using the FPL Hardwood Log Grades as a measure of quality trends and accomplishments. At the Crossett Experimental Forest the Crossett Log Grades for Southern Pine are being used to determine the character of timber cut from the management plots on the experimental forest. These same grades are applied to all trees 10 inches and larger in DBH so that the quality of the residual stand can be checked.

Northeastern.-- There are several forest management studies being carried on which use log grades as quality measures. Two studies have used the Otsego hardwood log grade system for sugar maple. The remainder of the studies are measured with the Hardwood Log Grades. In these studies the cut trees are graded separate from the residuals. This is being done in an attempt to determine the results of management on the basis of the quality of the yield with respect to the quality of the growing stock.

Southeastern.-- Foresters at this Station use the Hardwood Log grades and certain pine log grades or tree grades in their compartment studies. At the Santee Experimental Forest they have developed tree grades for loblolly and shortleaf pine based upon the Crossett Log Grades for southern pine.

In general, the forest management researchers have held off in the use of log grading systems on the basis of the fact that they need timber quality measures which will remain constant over a long period of time. They feel that the existing log grading systems are still in what might be called a state of flux. Therefore forest management research has decided not to use them.

2. Application by industry and others

The Working Group did not study the applications being made by industry and other public agencies in detail. However, the applications of log grading systems in industrial forestry are very important to the Forest Service in view of its policies regarding national forestry programs and problems. Therefore, the following discussion is justified even though it is limited in reliability and coverage.

Many individual firms have log grading systems of their own. Special industries in particular make extensive use of rather detailed grades. However, most of these log grades are based on sawn or veneered end-products. Poles, piling, and other round product specifications have not been translated back into log or tree grades to a similar extent. Neither are there any pulp grades which have been used to make pulpwood grades, although some companies have minimum pulpwood standards.

Name of grading system by region	Application by:	
	Industry	Other Federal or State
Pacific Northwest		
Columbia River Bureau log grades	x	x
Puget Sound Bureau log grades	x	x
Grays Harbor Bureau log grades	x	x
Southern Oregon Bureau log grades	x	x
Region 6 Ponderosa Pine log grades		x
Region 6 Associated Species log grades		x
California		
Northern California Bureau log grades	x	x
Hammond Redwood log grades	x	
Holmes-Eureka Redwood log grades	x	
Culkin's Redwood log grades	x	
Simpson Redwood log grades	x	
Modified Wildwood Douglas-fir log grades	x	
California Eastside log grades	x	x
California Westside log grades	x	x
Lake States		
NHHMA log grades	x	
Central States		
American Walnut Association log grades	x	
Hardwood log grades for Standard Lumber		x
Southern States		
Hardwood Log Grades for Standard Lumber	x	x
TVA use-classes for hardwood logs		x
American Walnut Mfrs. Assoc. log grades	x	
Crossett Southern Pine log grades	x	
Tomlinson's Walnut log grades	x	
Northeastern		
Hardwood Log Grades for Standard Lumber	x	x
NETSA hardwood log grades	x	
American Walnut Mfrs. Assoc. log grades	x	
NHHMA log grades	x	
Pack Forest tree grades		x
Otsego log grades		x
OPA white pine log grades	x	
Southeastern		
American Walnut Mfrs. Assoc. log grades	x	
Southern Pine Assoc. log grades	x	
Hardwood Log Grades for Standard Lumber	x	x

3. Summary of applications

The investigations of this working group have revealed a widespread use of log and tree grading systems of some sort. Some of the systems in use have been developed in an arbitrary manner, some on the basis of judgment, while a very few have been based on an analytical method of development. Some, it is suspected, even though widely applied, have questionable utility. Some of the better systems are applied quite precisely; others poorly. However, foresters appear to be aware of the need for an adequate system and appear to be thinking in terms of generally similar objectives and performance standards. The section to follow is the working group's synthesis of what these major objectives and standards of performance are.

II. DESIRABLE OBJECTIVES AND STANDARDS OF PERFORMANCE FOR LOG AND TREE GRADING SYSTEMS

The researchers who are developing log and tree grading systems must keep constantly oriented with respect to the objectives which are desired by those who need or are applying log and tree grading systems. The most encouraging conclusion of this Working Group was that all grading applications were aiming for the same few basic objectives. Furthermore, the desirable standards of performance were the same for most of the applications. Such evidence led us to the conclusion that the same few objectives and standards of performance can be used to coordinate a program of research in the development of log and tree grading systems. We present these objectives and standards in this portion of our report.

It may be well to note that the form and content of a timber quality evaluation system is governed by the objective or objectives the system must meet and how well it is desired that the system meet them. Any adequate grading system must meet one or more of the objectives. Rarely can the merits of any proposed system be judged unless these two elements are clearly set forth as background for judging. Many of the difficulties inherent in the present situation stem from the fact that information on one or both of these is lacking. The following discussions should fill this need.

A. MAJOR OBJECTIVES

Any grading system must meet one or more of several objectives in order to be adequate. The following were found to be the major objectives desired from the use of log or tree grading systems.

1. To determine the gross market value of a tree or a log, or of a group of trees or logs. The term "gross" is used in this objective in order to indicate that the cost of conversion is not a part of the determination of value. In other words, the gross market value refers to the actual dollar and cent value of the products produced from the trees or logs. The attainment of this objective in the application of a grading system is of primary concern to the timber appraiser.

2. To determine the relative gross value of a tree or a log, or of a group of trees or logs. In this objective the term "relative" is used to mean that the need is for a ranking of the material into good, medium, and poor categories, or into some other order of value or desirability. Graders who desire this objective do not necessarily need to have a dollar and cent value assigned to a particular grade within a grading system. The forester can make many of his forest management decisions with this knowledge of the most valuable rather than how valuable. The attainment of this objective can also satisfy the need of the timber appraiser if market value can be assigned to any one of the grades of material.

3. To determine the amounts of the various classes of end-products and/or grades of a given end-product class which can be obtained from a log or a tree or a group of logs or trees. Grading systems obtaining

this objective would serve their most useful purpose in guiding utilization decisions and in making it possible to record trends in the quality or usefulness of timber stands. By assigning current market values to the various classes or grades of end-product in the proportions in which they are estimated to be produced, an appraiser can determine either gross or relative market value as desired in objectives No. 1 and 2 above. Consequently, this objective may be considered the most important.

4. <u>To classify trees on the basis of their potential for growing into mature trees which will yield given end-products of high utility or high value in the future.</u> A grading system which obtains this objective would be most useful as a guide in the application of silvicultural practices. The development of grades to obtain this objective will require study of the relationships between growth characteristics and product characteristics. It will be very helpful to have grading systems which obtain objectives 1, 2, and 3 above as a basis for developing systems to meet this objective.

B. <u>CERTAIN STANDARDS MUST BE MET IN DEVELOPING AND APPLYING GRADES</u>

A better term for standards of performance might be "secondary objectives." These will refer mainly to how well and how easily foresters want to obtain the major objectives listed above. For purposes of discussion, standards of performance can be divided into two groups. The first group we shall call "developmental" and the second we shall call "application." All of the standards of performance must be specified before and adhered to during the development of log grading systems. Application standards are so labeled because they are the standards which do the most to guarantee easy application of the grading system. Keep in mind that each of the standards of performance helps control how well and how easily the forester obtains the major objectives.

1. <u>Standards are needed to guide the development and testing of grading systems.</u>

a. <u>The grades in a grading system must group the logs or trees so that the variability in value and/or product yields is reduced to a reasonable limit.</u>

The first step in the testing of an existing grading system or the development of new grading system is to define the population of logs or trees to be graded. The population may be broadly defined as all of the merchantable material of a given species for some given area or region capable of being made into certain end-products under a given conversion system. The Basic Concepts in a later part of this report contain guides for more precisely defining the population of logs or trees to be used in testing or developing grading systems.

Once the population is defined, estimates of the average log or tree values or end-product yields for the population can be made by appropriately converting a sample of logs or trees from the full range of sizes. The variation of the individual logs or trees around the

estimated population averages can be computed. A system of grading is in-tended to group the logs or trees in such a way that the total variation around the estimated averages for the groups (subpopulations) will be less than the variation without the grouping (whole population).

The true averages for the total population of logs or trees are actually never known. How close the estimates are to the actual averages in each instance will depend upon the natural variability of the individ-ual logs or trees, the range of log or tree sizes in the sample, and the number in the sample. If we assume that the range of sizes and the number of logs or trees in the sample to be used in testing or development of log or tree grades are adequate, our main concern can be directed toward the variability of logs or trees. This variability can be controlled within natural limits by grouping the logs or trees into grades (subpopulations). Therefore, the effectiveness of a grading system should be judged by the reduction in variability which occurs when it is used to segregate the logs or trees. From a statistical standpoint this is a problem in stratification rather than one of sampling distribution or application.

The variability of either value or end-product yields can be used to indicate the effectiveness of grading. The use of end-product yield varia-bility is complicated by the fact that there are generally from three to twenty or more end-product grades produced from a given log or tree. By weighting each end-product grade by current or other appropriate market value, it is possible to compute a single value for each log or tree, and to use variation of value per unit of volume as a guide in grade testing and development. Not only does this give a single expression to work with but it takes into account the relative importance of the several end-product grades.

The researcher who is testing or developing a grading system must know when it is necessary to further reduce the variability by revising or adding to the grading specifications. The answer to this question must come from knowledge of the accuracy desired by those who will apply the grading system and from knowledge of the natural variability in value. By studying the applications being made and the current and past research re-sults the Working Group was able to suggest a reasonable limit on varia-bility of value.

The Working Group recommends that the square root of the variance of value per unit volume should be 7 percent of the mean value per unit volume for each grade within a grading system. This variance may be from a regression or from an estimated mean. In order to use the specific limit of 7 percent a regression must be in terms of value per unit volume as a function of the volume produced or readily convertible to these terms. Variance from a regression will be an average if the variance of value per unit volume is heterogeneous. This limit on variability can be used satis-factorily no matter how the variance of value per unit volume is calculated. It should be noted that the estimated mean value when there is regression is the mean value per unit volume for all logs or trees in a given grade in the complete sample. The ratio of the square root of variance from regression to this mean value is not a commonly used statistical term. However, we will use it here with recognition of its meaning and limitations. Remember that this is only a guide in making decisions on the adequacy of grading specifi-cations.

b. Value and/or product differences between grades is necessary within a grading system.

A grading system should do more than just estimate with reliability. It should also segregate the logs or trees into grades that have differences in value or end-product performance that are statistically significant and of large enough real magnitude to justify the time and effort of applying the system. In the case of value differences it is possible to statistically compute the significance of the difference between one grade and another. For a given log size one grade should differ from another by not less than 10 percent of the mean value of the higher of the two grades under consideration. The differences in mean value between the several grades should be approximately equal. Because the specifications for a log grade within a grading system must define visible characteristics and take into consideration the necessity for fairly uniform end-product grade yields, the spread of dollar values per unit volume for a grade will overlap the spread of values of adjacent grades.

In certain instances the prices of the end-products may be such that very little value difference will exist between logs of different grades in spite of important differences in end-product grade yields. This will require that an analysis be made of the significance of the difference in yields of a few key end-product grades. In this manner a certain grade within a grading system can be retained even though it does not differ from the other grades by the aforementioned amount in value.

2. Application standards

Under this heading we have included those standards of performance which have to do with the ease and uniformity of the application of a grading system. These are important in the testing or development of grading systems.

a. Grade specifications were defined in this report as those terms or measures used to describe the visible characteristics of the logs or trees that are to be placed in a given grade. These specifications must be clear, concise, and understandable, and in terms that persons with experience or training in timber growing and harvesting can be expected to understand. They should not include any factors of judgment regarding the amount or quality of the end-product. Such statements are frequently found at the end of grade specifications and read like this, "This grade is expected to yield 20% of its net volume in select lumber." In most instances graders will need a set of definitions of terms to be referred to while learning grading specifications.

b. There should be a limited number of grades within any grading system. Six grades should be set as a maximum standard. The Working Group's experience indicates that grading systems with 6 or more grades either have one or two little-used grades or are very difficult to apply effectively. Any or all of these grades may include a further breakdown based on diameter.

c. Another standard of performance which the Working Group finds desirable is that a given grading system be applicable to a particular species over its entire commercial range. If the original data used to test or develop the grading system was a sample of the complete range of the species this standard will undoubtedly have been met. However, in the instances in which an existing system is to be extended to other areas, a test must be made to determine the differences that exist in the performance tables as well as in the variability found in the original logs and trees and in that found in the logs and trees in the new area. If the variability in the new area using an existing grading system is within the limits previously described, the grading system should be accepted for the new area. Still remaining is the test for differences in performance between the original and the new area. If performance tables in the new area in terms of value or end-product yields are significantly different from the original, then new performance tables must be determined for the new area. If it is not different, the performance tables for the species may be determined from all the data from all the areas sampled, including the new area or they may be left as is.

d. A grading system should cover, within a species or a species group, all of the trees or bole segments which are physically suitable for conversion into the end-product under consideration. This standard of performance is necessary in order to make a grading system give reliable results. In the development of a grading system the researcher must decide what logs or what trees are suitable for use in determining the specifications and the yield or value performance. A later portion of this report under the heading of "Basic Concepts" will help him meet this standard of performance.

e. In the application of any grading system, it is highly desirable that the same set of specifications be used for all species producing end-products of a similar or the same use-class. As a standard of performance, this has less importance than the ones previously mentioned. In view of the type of applications being made and of the needs which have been expressed, this standard of performance is worthy of consideration during any development work.

f. If several grading systems are developed for a species, each for a different class of end-product, it will be possible for a tree or log to have several grades, one for each use-class in which it can be placed. This does not seem to be desirable. Therefore, such overlapping grading systems should be combined when possible by making appropriate adjustments in the specifications. The possibility of doing this can be judged by determining whether or not the combination grades meet the objectives and performance standards for each use class involved. For example, if veneer log grades 1, 2, and 3 for a given species overlap the first 2 grades of sawlogs, all possibilities for changing one or both the systems to get uniformity should be investigated. The result might be a grading system whose grades 1, 2, and 3 have yields estimated for both lumber and veneer, while grade 4 and any others give yields only in terms of lumber. This standard of performance does not have the importance of the others listed above.

Up to this point the Working Group's attention has been on what a grading system should do and how well and how easily it should do that. We have called these objectives and standards of performance. They are what we condensed from the information gathered in the field and from literature. Having set these down in rather definite terms, the Working Group turned its attention toward the basic concepts necessary in the development and application of grading systems. The following section is the presentation of these basic concepts.

III. BASIC CONCEPTS IN THE DEVELOPMENT AND APPLICATION OF GRADING SYSTEMS

The broad species, products, and area coverage of this analysis made it impossible for the Working Group to present specific fundamentals that would take care of all the different circumstances. However, we have stated five basic concepts which are broad fundamentals. These concepts will guide the development of any grading systems and assure proper application.

A. BASIC CONCEPTS

1. Gross valuation should be made on an end-product basis

The end-products must have well-defined standards of usefulness or end-product grades before a grading system can be developed for logs or trees that produce the end-product. Furthermore, market values must be available for each of the end-product grades. For example, when grades or various qualities of an end-product exist, as in the case of hardwood factory lumber, logs and trees can be graded on the basis of how much can be produced of the various grades of such end-products. This satisfies objective No. 3 as described earlier in this report. However, if an end-product is essentially of one single quality, i.e., either it will or will not serve a purpose, logs or trees can only be placed in use-classes on the basis of whether they will or will not make this product. Currently pulpwood of many species is marketed as being essentially of one single quality. This further illustrates the distinction we have made between classifying and grading in the Introduction of this report.

The Working Group has already pointed out in the accuracy and segregation standards of performance that statistical analyses would be based upon value. Therefore, we now specify that the researcher must have values which to assign to the various end-product grades. The most useful values that he can assign are those determined from transactions on the open market. The important thing to keep in mind here is that the best possible expression of values of end-product grades is needed in order to satisfactorily accomplish Objectives 1 and 2. Several difficulties arise in obtaining and using the desired values. True market prices are hard to come by because market transactions are not generally public information. Another difficulty arises when the stage of conversion at which market transactions take place varies from one area to another and from time to time. Furthermore, the researcher cannot always trace the product yield information for each log to the physical condition at which transactions actually take place. In the case of softwood lumber, the best point at which price information can be obtained is where the lumber is marketed as dried and surfaced. The researcher must follow through several conversion processes and collect field data in costly, difficult, and sometimes physically dangerous circumstances.

This basic concept does not prevent the researcher from using good judgment in adjusting log and tree grade specifications to obtain good results in terms of end-product grades. The Working Group knows that the researcher must have this concept in order to use his judgment and his statistics in combination for decision-making.

2. Minimum specifications are needed

Minimum specifications for a use-class must be established. These will indicate to the researcher the poorest logs or trees which he may consider suitable for inclusion in a use-class for which quality grades are to be developed. These minimums will describe physical characteristics of the logs or trees. They may be based upon current methods and costs of conversion, even though costs of conversion are specifically disregarded in the subdivision of any use-class into several quality grades.

A good guide to the use-class floor specifications are those broad merchantability limits generally used in industry. These include relation of gross to net volume, straightness, size, and sometimes so-called "roughness". This basic concept helps to assure that a grading system will meet the objectives and standards of performance, as set forth in this report. Use as an example the standard of performance requiring that all logs and trees suitable for a given product be included in the field data. The use-class minimum as set forth in this concept will also be the minimum for the lowest grade in the use-class.

3. Grading specifications should include only the visible and important indicators

Log or tree grading specifications must include only those visible characteristics that logs or trees exhibit and which can be consistently identified and evaluated. Judgment factors, such as the amount of a given end-product grade that can be produced, must not be included. Here we make a distinction between the terms "defect" and "cull". Agricultural Handbook No. 4 distinguishes defect and cull for us as follows:

> "Since a defect that reduces volume (e.g., rot) is entirely
> different from a defect that reduces utility (e.g., knot),
> it is logical to call scalable defects 'cull,' and to apply
> 'defect' only to those imperfections that lower the quality
> of the product into which sound wood in the tree or log
> will be converted. This distinction is not always clear-
> cut; cull when affecting only small areas, may be left in
> the product, where it impairs strength or utility and thus
> becomes a defect."

In a study of the yields of end-products from logs or trees, the influence of all defects upon the usefulness or the grade distribution of the end-product can be determined. Specifications must include those defects

which do have a significant influence upon grade and value yields and have exterior indicators. However, there are some internal wood blemishes that affect the grade or value of the product that have no exterior indicators. These may be either sound or rotten. Such "hidden defects" must be excluded from the specifications. Their effect is reflected in the dollar value or distribution of yields of the grade or class. In this connection, exterior means surface. In the case of log grades to be applied to logs which have been cut, surface includes ends.

In order to meet the standard that a grading system should apply to small groups of logs or trees, grade specifications may include exterior indicators which only occur in rare instances. This makes it possible to properly classify logs or trees containing these rare instances so that the value or product estimates for small groups of logs or trees will be reliable.

In numerous grade development studies researchers have reported that cull as defined herein had an influence on the end-product and value per unit of a given log. Some researchers conclude that the reduction of the gross volume of a log due to cull results in a decrease in the per unit value. Others claim that a reduction in gross volume of a log or tree due to certain types of cull results in an increase in the value per unit. Defect or cull observed in the ends of logs during a study may have a significant influence upon the performance of the log grades. If such defect or cull has no exterior indicators they cannot be included in log grade specifications to be used in standing timber. Such defect or cull should be footnoted in the log grade performance statements. This will assure the proper application of the log grading system.

When such a log grading system is to be applied to logs after being cut, the end defect or cull limitations may be added to the specifications. Of course, different performance tables will be needed to correspond to the added specifications.

The Working Group found that costs of conversion in grade development and in grade specifications cloud the meaning and limit usefulness. Therefore, log or tree characteristics that control or influence the cost of converting logs or trees into end-products should not be included in grading specifications. However, some characteristics that influence costs also influence the physical yields and/or end-product grade distributions. If this be the case, then of course that characteristic must be included in the specifications. For example, a log should not be down-graded simply because it may cost more to saw it into lumber than its products are worth. Omission of conversion cost as a grading factor will permit a more accurate description of the physical and economic characteristics of any group of logs or trees. It will also permit more flexibility in the use of the grading system.

The above limitations on the type of information to be included in log or tree grading specifications will permit foresters to attain the standard of performance which stated that the specifications must be clear, concise and understandable.

4. The conversion system is important in controlling the end-product yields.

The performance of a grade within any given grading system will depend upon the methods and equipment used for converting the logs or trees into end-products. The conversion method chosen must be one that is judged to be capable of, and efficient in, converting the material into all the grades of usefulness that are established for the end-product for which quality grades are being developed. This may be one of the most difficult points for researchers to agree upon. However, the Working Group is certain that this decision on the conversion method must be made and adhered to before an adequate grading system can be developed. Differences in equipment and/or method do have a significant influence upon the distribution of end-product grades or upon the gross unit value that can be obtained from a given log or tree.

This fact gives greater emphasis to the need for using, in the development of a grading system, a single, appropriate, completely defined conversion system. This need not and generally will not represent an "average" for the region to be covered by the system. It will, however, be one that is practical and will protect the "public" interest, with the "public" being considered as a timber grower or seller on the one hand, and the timber converter on the other. Adherence to this concept may significantly alter the course of studies in that it may be necessary to secure a greater degree of industry cooperation than often has been attained in the past. It will also mean that field work should not be carried out until appropriate conversion practices have been thoroughly outlined.

Having developed a grading system on a definite and appropriate conversion basis, the grading specifications can remain the same as long as the basis is acceptable. When other methods or equipment are accepted as superior or more appropriate, the yields and/or values (performance) can be recomputed.

Some researchers have artificially converted or otherwise analyzed the properties of logs or trees by methods not accepted for industrial practice. The Working Group contends that a log or tree grading system cannot satisfy any of the major objectives unless it establishes a relationship between grading specifications and end-product yields. This viewpoint stems from the definition of quality and from the stated objectives of an acceptable grading system. Therefore, any such special research method of conversion to be used in grade development must convert the logs or trees into salable end-products, either directly or indirectly. For example, researchers at the Lake States Station have made a study in which logs or trees were dissected into small flitches.

This study is an illustration of the point in question. Research can proceed in any direction but the test of the results is whether or

not they meet the stated objectives. A study, such as the Lake States effort, that uses concepts other than commercial end-products, as an intermediate step in determining product output in value, is an extension of the use of specified conversion systems. It has an advantage in that much basic knowledge of timber development, not available from studies that involve the usual procedures, may be gained by its use.

5. A grading system should remain unchanged as long as possible

Several of the factors that must be held constant in order to develop a satisfactory grading system will change with changes in time and place. In order to make any grading system useful over the widest area for the longest period of time, adjustments for such changes must be made only in the performance data after the system has received acceptance in the field. This will mean that the specifications will remain the same insofar as possible, but the performance (i.e., the yield or value tables) will be changed. These changes in performance should be made only when the difference between the original performance and the new are sufficient to justify the effort. The Working Group expects changes to occur in end-product grades, conversion systems, use-classes, value, and in several other aspects of grading.

The foregoing basic concepts are purposely broad and general in nature. The many species and diversity of end-products keep us from being specific. The researcher must plan his work in the framework of these basic concepts if his grading system is to obtain the major objectives with the standards of performance as set forth in this report.

IV. UNIFORM RESEARCH TECHNIQUES

At the Quincy meeting, the National Log Grade Committee requested a task force to thoroughly investigate the matter of research techniques. It soon became apparent that this could not be done in a short time. This Working Group agreed to investigate the research techniques which have been used and to suggest uniform research techniques if possible.

The use of uniform research techniques in log grade development is desirable for several reasons. First, it would speed up the development and testing of log grades over all the nation if the techniques were well conceived and approved. The development work has been spread out among a number of persons and projects--each with its own methodology.

Second, the processing and analysis of the large amount of data used in log grade development could be done more economically by electronic computors if uniform techniques were used.

Third, the use of uniform research techniques would make it easier to pass judgment on the acceptability of existing or proposed new grading systems as standards for the Forest Service.

A. Major Kinds of Techniques Needed

We learned of a great number of techniques which have been used in log and tree grade development work. Among these were mark-sense tallying methods, the use of photography, the use of electronic computers, logarithmic transformations, and so forth. However, only a few of the techniques studied were of primary importance testing existing grades or developing new grades that would meet the recommended objectives, standards, and concepts. Other techniques were not critical in the development or testing procedures. We would like to describe three critical processes in which techniques are needed.

1. Techniques are needed for the testing and selection of the controlling factors to be included in grade specifications. This includes the determination of breaking points between grades for certain factors such as knot size. Such techniques could be used to examine the existing grading systems and would help to make improvements in them.

2. Methods are needed for comparing the effectiveness and reliability of grading systems and of grades within a system. In this report we have recommended that value be used as a basis for a statistical analysis. We have also pointed out that end-product yields would be a better basis for analysis. However, statistical methods have not yet been adapted to the analysis of product yields.

3. Techniques are needed for the calculation of end-product performance data. These data may be presented in the form of curves or tables. Such calculations are needed after the specifications are developed and prior to application. They are also needed when and if it is decided that special or local performance tables are needed.

B. The Techniques That Are Available

  1. For Selecting Specification Factors

        The selection of the factors which control value and product
yields, and which are therefore included in grade specifications, is
critical in the development of grades. We have shown that in the
"judgment" method of development end-product yields are selected as
grading factors. In the "arbitrary" method the factors are selected
by experienced woods and mill men on the basis of their knowledge
regarding the relation of timber characteristics to end-product grades.
In the "analytical" method all factors suspected of being important are
tested statistically in order to select the significant ones..

        The "judgment" method is inadequate because it does not provide
specifications that are clear, concise, and understandable nor can they
be uniformly applied.

        The "arbitrary" method alone is inadequate. It does not satisfy
our need for selecting all those factors that control value and product
yields and only those that are important. The Working Group has not
used the term "arbitrary" in a derogatory sense. The selection of the
important factors to be considered in the development of any grading
specifications must be made by trained and experienced men. However,
we believe that every possible mathematical or statistical technique
should be used as a basis for testing the factors which are expertly
selected.

        The "analytical" method has no place in grade development
without the prior expert determination of possible grading factors.
The greatest limitation on the "analytical" method in developing
grading specifications is our inability to express certain important
grading factors in numerically simple terms. The knot-count system was
used in the analytical development of the Interim Southern Pine Grades.
The recent computing machine program for regression analysis by
Grosenbaugh has increased the possibilities for the analytical develop-
ment of grading specifications.[1/] However, the need for expert selection
of grading factors and for the numerical expression of certain factors
still remains.

        The Working Group cannot suggest any uniform technique for
selecting grading factors. The research program recommended in this
report must include a considerable amount of work on these techniques.

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      1/ Grosenbaugh, E. R. The elusive formula of best fit: A
comprehensive new machine program. Southern Forest Experiment Station.
Occas. Paper 158, 9 pp., 1958.

2. For Testing the Effectiveness and Reliability.

On pages 18 and 19 of this report it is recommended that the variance of the value per unit volume be used to measure the effectiveness of log or tree grading systems in reducing variability. If this is to be done it is necessary to have methods or techniques for calculating the variance. Other statistics also must be calculated but the variance of value per unit volume is one which can not always be considered a standard or straightforward calculation.

If a grading system is developed by analytical methods, the testing of the system by statistical methods is carried out during the process of selecting the grading specifications.

We realize that under the program recommended herein the grading specifications will not always be analytically developed. In fact a great deal of effort will be spent on the comparison of existing grading systems in order to select the most effective ones and on the testing of grading systems for possible use on other species or in other areas. Therefore techniques are needed for such testing and this includes the estimation of variance of value per unit volume.

The Working Group found that there had been very little recorded use of such techniques. The publications on the Interim Southern Pine Log Grades includes information on the technique used in testing the grading system after analytical development.

The Minutes of the 1957 National Log Grade Committee meeting at Quincy, California includes an article describing the statistical technique used on hardwood log grades. Further information on this technique will be included in a forthcoming publication by the Forest Products Laboratory. The Laboratory statistician is also making an exhaustive study of testing techniques.

The Working Group suggests that each of these techniques be considered for use by researchers under this program. The techniques of testing will be an important part of this coordinated program.

3. For Calculating Performance Data

Most performance data is needed in the form of end-product yields by grades or by size classes within grades. The simplest data is that given as raw averages. Another method of presentation is as freehand cumulative curves or as tables compiled from such curves. A third method is the computation of curves of end-product yields. The first two methods are rather straightforward and the techniques used are not unusual.

Very little work has been done by the third method. The Working Group would like to draw attention to the IBM 650 program for computing performance data by Floyd Johnson at the Pacific Northwest Station.[2] This may serve the needs of some of the projects recommended in this report.

Conclusions

We have shown that three major kinds of research techniques are critical in grade studies. These are for grading factor selection, for testing effectiveness of grading systems, and for calculating performance data. We have briefly referred to the available techniques and their limitations. We recommend that any program of log and tree grading research should be coordinated regionally and nationally in order to make the most effective use of present techniques and of those techniques that will necessarily be developed in such a program.

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[2] Johnson, Floyd A. Specifications for processing mill scale study data on a type 650 electronic machine. Pacific Northwest Forest and Range Experiment Station, Res. Note 133, 10 pp., October 1956.

V. THE ADEQUACY OF EXISTING LOG AND TREE GRADING SYSTEMS

The check list in the Appendix of this report lists over 50 log and
tree grading systems which are or have been in use in the United States.
There are numerous other systems not in the list. However, those included
cover the major species with which foresters and wood users are concerned.
It is not possible to test the adequacy of each of these grading systems.
The table on the following page is a condensation of all of the informa-
tion that is pertinent to the adequacy of the main log grading systems in
use by the Forest Service. Only the critical objectives, standards of
performance and basic concepts are included. This does not mean that the
remaining criteria are unimportant; they are only of lesser importance
than the ones given. A detailed analysis was not made of each of these
grading systems. In most instances the Working Group was able to judge
whether or not a system was adequate in a particular objective, standard,
or concept after only a brief review of the literature. An indication
in the table that a particular grading system is inadequate in a certain
respect does not mean that this system cannot be made adequate through a
properly directed research effort. It does mean that no indication has
been found that the system is adequate in that particular respect.

In the table, a number and key words are used to indicate which
objective, standard of performance, or basic concept is being considered
in a given column. You may refer to previous portions of this report
for further details on these objectives, standards, and concepts. Also
included in the table is the method of development believed to have been
used. In addition, a column is used to indicate the end-product use-
class which the grading system is measuring or evaluating.

Table of Characteristics of Some Log Grading Systems in Use by the Forest Service

Species and grading system	End-product use-class	Development method	Objectives[1]			Standards of performance[2]				Basic concepts[2]		
			1 Market value	2 Relative value	3 Product yields	1a Varia-bility	1b Segrega-tion	2a Clear specs	2d All material	1 Value basis	2 Minimum specs	4 Conversion system
Ponderosa Pine												
Region 6 Log Grades	Lumber	Arbitrary	Yes	Yes	Yes	No	Yes	No	No	Yes	No	Yes
California Eastside	"	"	Yes	Yes	Yes	No	No	No	No	Yes	No	No
California Westside	"	"	Yes	Yes	Yes	No	No	No	No	Yes	No	No
Forest Survey 4-grade	"	"	No	Yes	No	No	No	No	No	No	No	No
Douglas-fir												
Columbia River Bureau	Lumber	Judgment	No	Yes	No	No	Yes[3]	No	No	No	Yes	No
Columbia River Bureau	Veneer	"	No	Yes	No	No	Yes[3]	No	No	No	Yes	No
Region 5 Wildwood	Lumber	Arbitrary	Yes	Yes	Yes	No	No	No	No	No	No	No
Region 6 Assoc. Species	"	"	Yes	Yes	No	No	No	No	No	No	No	No
Redwood												
Dolbeer and Carson	Lumber	Arbitrary	Yes	Yes	Yes	No	No	No	No	No	No	No
True Firs												
Dinuba white fir	Lumber	Arbitrary	Yes	Yes	Yes	No	Yes	No	No	No	No	No
Northern White Pine												
NETSA log grades	Lumber	Arbitrary	No	Yes	Yes	No	No	No	No	No	Yes	No
Eastern Spruce & Hemlock												
NH&HMA grades	Lumber	Arbitrary	No	Yes	Yes	No	No	No	No	No	Yes	No
Eastern Hardwoods												
Forest Prod. Lab grades	Factory lumber	Analytical	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No
Southern Pine												
Interim grades	Lumber	Analytical	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Crossett grades	Lumber	Arbitrary	Yes	Yes	Yes	No	No	No	No	No	Yes	No

1/ Answers indicate whether the system expressly sought the objective.
2/ Answers indicate whether the system had such a standard or was based on such a concept.
3/ Product differentiation is obtained by judgment only.

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Conclusions

The main species of species groups were given special attention and found to be inadequately served by existing grading systems. The following are the main inadequacies for the major species groups.

1. The systemsfor the western pines (mostly ponderosa) are entirely void of accuracy information, do not have clear, concise specifications, fail to properly account for cull in application, and do not place any limit on what can be included in the poorest grade.

2. Most of the Douglas-fir grading is done under one of the grading bureau systems. These systems have two particularly undesirable characteristics:

   a. The specifications are loose and the grade of a log is controlled in the final analysis by the judgment of the grader as to what can be recovered in terms of product.

   b. There are no data on the value or product performance, except that a minimum is specified in the grading rules.

3. The Hardwood Log Grades for Standard Lumber are not entirely satisfactory in all applications, particularly in the standing tree. Another problem in hardwoods is lack of adequate specifications for use classes other than factory lumber. There are also deficiencies in information on grading factor identification and evaluation, and on yield patterns for certain species.

4. The southern pine grading systems fail to indicate the accuracy of performance data and do not cover all the types of end-product being made nor a complete range of the raw material being used.

5. In the northern softwoods the major shortcomings of the grading systems are lack of performance data and accuracy and the lack of clarity in the specifications. The grading systems for these species were almost all developed by the arbitrary method.

VI. A PROGRAM OF RESEARCH

A. GENERAL

The current work of the Forest Service on the development of log and tree grading systems is limited. Because of the small size of the program as judged against the needs, results are meager and slow in appearing. Although a coordinating system exists to cover such studies, it is inadequate. The number of functions involved, the need for local information, and the time pressures involved, have often caused us to proceed with field work at a race-horse pace and without full planning and staffing for the entire job.

The Working Group recommends the following program of research in order to speed up the testing and development of needed log and tree grading systems. We believe that the coordination of all the Forest Service research efforts under this type of program will not only result in speed but in efficiency as well.

B. MAJOR PROJECTS

The Working Group recommends that there be 5 major projects in grade testing and development and one major project in basic timber quality problems. The following discussion describes these.

1. Log Grade Testing and Development Projects

We recommend that there be 5 major research projects. These are:

a. Ponderosa pine and certain other softwoods.

b. Douglas-fir and certain other softwoods.

c. Southern pine and certain other softwoods.

d. Eastern white pine and certain other softwoods.

e. Hardwoods, both eastern and western.

Each of these 5 major projects will concentrate initial work upon the testing and/or development of a tree-log grading system, a log grading system, or a tree grading system depending upon the most urgent immediate needs. In most cases the most urgent need is for tree-log grades, i.e. log grades that can be applied in the standing tree. It must be recognized that the development of any one of these systems will contribute to the others. Each project will coordinate all the work being done on a species, expand on it, and begin new work. This will make it possible to establish all the necessary types of grading systems for a species in the shortest time.

Under each of the major softwood projects the term, "and certain other softwoods" is used. This term refers to those species which are associated with the major species and/or are manufactured

into end-products very similar to those being made from the major species. Some jurisdiction problems may arise for some of these associated softwoods. In such cases the line project leader will assign a species to the proper project.

The Working Group wants each of the initial studies given in the next section to satisfy the most pressing need for a given species and use-class. However, we do not intend that any study be done in a vacuum. The coordination we are seeking through the recommended technical administration of the projects will take care of the need for making each study contribute information to all other studies, current or proposed. For example, if a ponderosa pine project study is being made to improve existing grading specifications, the data should be recorded by trees, if at all possible. This will contribute to any later study of tree grades or problems of application in standing trees.

2. A Basic Investigation Project

Timber quality study of a pioneering nature is needed. We recommend that a project be set up to cover such work. It should be aimed at investigating promising new concepts in quality grading such as those proposed by Grosenbough, McCormick, and Toole at the Timber Quality Conference. Another line of research under this project might be the development of end-product grades where none exist, such as hardwood veneer or pulp. As the term pioneering implies, there would be considerable freedom of study under this project.

C. INITIAL STUDIES UNDER EACH PROJECT

Following are the Working Group's recommendations of the initial studies to be made under each of the major projects. We feel that these initial studies will cover the most urgent needs. They also help to indicate to us what can be realistically achieved with the recommended staff and funds.

1. Log grade specifications for lumber logs of ponderosa pine.

(a) Objective: The existing lumber grades for western pine are going to be with us for some time. Therefore, the objective of this study will be to seek uniform log grade specifications for grading ponderosa pine lumber logs.

(b) Scope: To meet the study objective the researcher may find that an existing system (or a combination of the best features from several existing systems) will satisfactorily meet all grading objectives and standards of performance. Or it may be that an entirely new system will have to be developed. However it is emphasized again that an acceptable system is one whose developmental data or subsequent testing covers the entire commercial range of the species.

(c) Assignment: A leader and three technical men should be assigned to this project. This group should be headquartered at the California Forest and Range Experiment Station.

Current work under the existing line project will be coordinated through the technical administration of this program.

(d) Duration: An acceptable uniform set of log grade specifications for Ponderosa pine lumber logs should be ready in two years. Complete testing and application may take an additional year.

Upon completion of the Ponderosa pine studies of certain other softwoods should be made. These should include western white pine, sugar pine, lodgepole pine, Engleman spruce, white fir, red fir, and redwood.

2. Log Grade Specifications for Douglas-fir lumber logs and veneer logs.

(a) Objectives: Because of the close relationship between veneer and lumber in the general utilization and production of Douglas-fir the initial study objective is the development of log grade specifications for both veneer and lumber logs.

(b) Scope: Considerable effort has been expended in Douglas-fir log grade development. It is intended that this project (just as in the case of Ponderosa pine) will make use of all existing information and if possible adopt and/or improve an existing system. It may be necessary to develop an entirely new system.

(c) Assignments: A project leader plus two technical men should be assigned to this project. The project should be located at the Pacific Northwest Forest and Range Experiment Station.

(d) Duration: This objective should be met in 3 years. The project should be continued until the certain other softwood species have all been covered. The main species involved are western hemlock, western larch, western red cedar, and sitka spruce.

3. Standardization of the Interim Southern Pine Log Grades for Yard Lumber

(a) Objective: The present Interim Southern Pine Log Grade are now being tested. This study should aim at completing this testing and modifying the system, if necessary, to make acceptable as standard for the Forest Service.

(b) Scope: This study should consider the influence of site, milling method, species, and other important factors on the performance of the grades under the present specifications. This should be done for the entire commercial range of the southern pines.

(c) Assignment: A project leader and 2 technicians should be headquartered at the Southeastern Station on this initial study of a Southern Pine Project.

(d) Duration: A grading system ready for acceptance as standard should be ready in one year. Before this study is completed it would be desirable to begin studies of grades for southern pine construction lumber logs and for cypress lumber logs under this project.

4. Standard Log Grade Specifications for Eastern White Pine Lumber Logs

(a) Objective: The objective of this study should be to develop standard log grades for eastern white pine lumber logs.

(b) Scope: The log grades should be applicable in the Northeast, Lake States, Appalachians, and Central States. They should cover lumber as the end-product.

(c) Assignment: One man should be assigned to this initial study at the Northeastern Experiment Station.

(d) Duration: With the available data and good cooperation a set of acceptable log grades should be available for white pine in 2 years.

5. Refinement and Extension of Performance Data for the Hardwood Log Grades

(a) Objective: The objective of this initial study is to refine the end-product yield data which is now available and to secure new data for those species not otherwise covered.

(b) Scope: Refinement work will cover all the species. New data is needed for hickory, ash, elm, northern red and upland southern red oak, and black cherry. Performance tables are needed to cover logs with varying amounts of end-defects and cull.

(c) Assignment: A project leader and 2 technicians should be assigned to this work with headquarters at the Forest Products Laboratory.

(d) Duration: This initial study should be completed in two years or less.

Studies in the hardwood project we suggest to follow this study are: Grades for hardwood construction lumber logs, veneer log grades for yellow birch and southern hardwoods, and tree grades for selected species based on the log grades.

6. Pioneering Project in Tree Grading

(a) Objective: We suggest that the initial study should investigate the possibilities for the use of an objective tree grading system.

(b) Scope: This study should be limited to a consideration of the proposals of Toole, Grosenbaugh, McCormack, and certain others who wish to establish tree quality grades in such a manner as to permit application without a specific end-product in mind. The study should be further limited to one northern hardwood, one southern hardwood, one southern softwood, and one western softwood.

(c) Assignment: One man with imagination and experience should be assigned and headquartered at the Forest Products Laboratory. The interest and ability of the man will determine whether our suggested objective or some other will be studied.

(d) Duration: Indefinite. However, this should become definite as soon as the man on the job can make a study plan of limited scope similar to that given above.

D. ORGANIZATION AND ADMINISTRATION

1. General Administration and Supervision

Final technical and administration responsibility will rest in the Branch of Research with one of the division directors. This director will probably find it necessary to add one or more men to his staff to handle the program of projects. The number and duties of such men can be considered flexible. One probably should be a general assistant. It may be desirable to have regional leaders covering Eastern and Western projects. Or one or two subject matter specialists might be included on this staff. At the most the director should require a total of 3 men. We believe that staff at this level is necessary to gain the coordination that is now lacking in grading research.

2. Project Staff

General: Each field project will require the application of knowledge from one or more of the following fields: Wood utilization, wood technology, economics, forest management. To staff each project with the entire range of subject-matter specialties would be costly and inefficient. Therefore, the following team approach will be used.

a. Each project staff will collaborate with other research staff members in the local experiment stations and with the technologists at the Forest Products Laboratory. Such an arrangement will provide each project staff with suitable advice on minor technical problems which arise. When major consultation is needed, a study in some division or at the lab may be separately financed. The Laboratory should play a large part in each of the projects, particularly in the basic aspects of the studies.

b. Each project staff will use the technical guidance of an advisory committee. This committee may consist of the existing regional log grade committees or may be established especially for this purpose. Membership should include foresters in timber management and state and private forestry of national forest administration, forest survey, and other research divisions.

c. Field data collection in grade testing and development calls for a large staff with considerable training and experience. Each project staff cannot collect such data without the cooperation and assistance of National Forest Administration, other research divisions, and other local public and private organizations. It will frequently be possible to enter into cooperative agreements with other research agencies, such as state experiment stations and forestry schools.

The staff of the six projects at the outset should be organized as follows:

a. Ponderosa Project--A leader and 3 technical assistants.

b. Douglas-fir Project--A leader and 2 technical assistants.

c. Hardwood Project--A leader and 2 technical assistants.

d. Southern Softwood Project--A leader and 1 technical assistant.

e. Northern Softwood Project--A leader.

f. Pioneering Quality Grade Project--A leader.

Leaders should be GS 12 or 13. Men with proper background and experience are in limited supply, and recruiting will be difficult. Leaders in particular must be able to operate with wide latitude for independent action with a minimum of supervision.

E. FINANCIAL REQUIREMENTS

1. Current Situation

At present there is no single specific allotment of funds for grading research work. About $110,000 per year is being spent on log and tree grade development and testing under line project FS3-el-2.

Unknown additional amounts are being spent in forest economics, forest management, and national forest administration toward log and tree grade development.

2. Requirements

The program we recommend will require an annual expenditure of $400,000. This would be expended as follows:

Salaries and staff maintenance	$250,000
Temporary help and expenses	100,000
Rental of computing and utilization facilities	50,000
Total	$400,000

Total Number of Grade Yield Studies,
Number of this total in which the logs or trees were diagrammed,
Individual recovery taken, and for which raw data is available,
by Species,1/ November 1957

| Species | Number of studies2/ | | | |
	: Total	: Diagrammed :	Individual : recovery :	Available raw data
Ponderosa Pine	43	14	28	27
Douglas-fir	29	10	25	22
True Firs	11	5	11	8
Western Hemlock	3	0	2	1
Western Larch	4	2	3	3
Lodgepole Pine	2	1	2	2
Western Cedar	1	1	1	1
Western White Pine	5	2	3	2
Engelmann Spruce	1	1	1	1
Sugar Pine	8	2	5	4
Redwood	5	1	3	3
Eastern White Pine	6	1	4	2
Southern Pine	17	4	15	15
California Black Oak	1	1	1	1
Aspen	2	1	1	1
Birch (alone)	1	1	1	1
Maple (alone)	2	1	2	2
Walnut (alone)	3	2	3	3
Mixed Hardwoods3/	59	24	42	39

1/ This does not include numerous mill studies made that did not involve grading of some sort.

2/ In instances in which up to three species were included in the same study the table repeats these in the tabulation. That is why column totals are not given.

3/ Some studies are reported as one even though numerous mills may have been included.

PARTIAL CHECKLIST OF LOG AND TREE GRADING SYSTEMS

The purpose of this checklist is to make a record of those grading systems that are general public information. Those that are marked with an asterisk(*) were in use by the U. S. Forest Service in 1957. The information in parentheses is added to indicate something of the origin of the system or to otherwise distinguish it from similar systems. The underlined number following each system refers to the bibliographic item number of the publication which gives the most information about the system. The bibliography used was "Grading Logs and Trees for Quality" by Frances J. Flick, July 1955.

I.   Softwoods--West

1. Ponderosa Pine

   * Region 6 Log Grading Rules of 1938 (Lodewick) 200
   * California Eastside Log Grades (6 grades, Brundage)
   * California Westside Log Grades (4 grades) 174
   * Intermountain Forest Survey Log Grades (4 grades, I. V. Anderson)
     U. C. Grades for 2nd Growth (Krueger, Grah, Zivnuska) 197
     Feather River Conference Grades of 1939 (Very similar to Inter-
       mountain Forest Survey) 232
     Brundage's Compensated Knot Count System of Log Grades (1938) 233
     R-1 1914 Log Grades (3 grades)
     R-1 1925 Log Grades (3 grades)
     R-1 1932 Log Grades (Based on A.C.M. Studies, 4 grades)
     R-1 1937 Log Grades (5 grades)
     Anderson's Tree Grades (6 grades) 164

2. Douglas-fir

   * Grays Harbor Bureau Log Grades[1/] 190
   * Columbia River Bureau Log Grades 177
   * Northern California Bureau Log Grades[1/]
   * Puget Sound Bureau Log Grades[1/] 221
   * Southern Oregon Bureau Log Grades[1/]
   * Region 5 Wildwood Log Grades
   * Intermountain Forest Survey Log Grades (4 grades, I. V. Anderson) 232
   * Region 6 Associated Species Log Grades

   _____

   [1/] These have essentially identical specifications.

3. Redwood

    * Dolbeer and Carson Log Grades (Region 5) 173
      Hammond Redwood Log Grades 207
      Pacific Redwood Log Grades
      Holmes-Eureka Log Grades 192
      Simpson Redwood Log Grades 207
      Culkins Redwood Grades
      Dolbeer and Carson Tentative Log Grades 172

4. True Firs, Spruce, Larch, and Hemlock

    * Tentative White Fir Log Grades (Adapted from Region 5 Wildwood)
    * Puget Sound Bureau Log Grades 221
    * Grays Harbor Bureau Log Grades 190
    * Southern Oregon Bureau Log Grades
    * Northern California Bureau Log Grades
    * Region 6 Associated Species Log Grades
    * Intermountain Forest Survey Log Grades (4 grades, I. V. Anderson) 232
      Anderson's Western Larch Veneer Log Grades 163

5. Lodgepole Pine

    * Intermountain Forest Survey Log Grades (4 grades, I.V. Anderson) 232
    * Region 6 Associated Species Log Grades

6. Western White Pine

    * Intermountain Forest Survey Log Grades (4 grades, I.V. Anderson) 232
      Bradner and Fullaway White Pine Log Grades 1928 168

II. Softwoods--East

1. Eastern White Pine

    * NETSA White Pine Log Grades 92
      Interim Log Grades for Southern Pine 151
      Pack White Pine Tree Grades
      NH&HMA White Pine Log Grading Rules 65
      Trial White Pine Log Grades (N.E. Station)
      Otsego Coop. White Pine Log Grades 68
      OPA White Pine Log Grades 31

2. Norway Pine

      NETSA Norway Pine Log Grades 92
      OPA Red Pine Log Grades 31
      NH&HMA Grading Rules for Norway Pine Logs 65

3. Hemlock

* Northern Hardwood and Hemlock Log Grades (NH&HMA) 65
  NETSA Hemlock Log Grades 92
  OPA Hemlock Log Grades 31
  Pack Hemlock Tree Grades
* Interim Log Grades for Southern Pine 151

4. Spruce and Fir

  NETSA Spruce Log Grades 92
  NETSA Balsam Fir Log Grades 92
* OPA Log Grades for Spruce and Balsam 31
* Interim Log Grades for Southern Pine 151
* Northern Hardwood and Hemlock Log Grades 65

5. Southern Pine

* Interim Log Grades for Southern Pine 151
* Crossett Log Grades for Southern Pine 141
* N. E. Adaptation of Crossett Grades 89
  OPA Log Grades for Southern Pine 31
  Tree Grades for Loblolly and Shortleaf (SE Station) 148
  1935 FPL Log Grades for Loblolly and Shortleaf 144
  1931 Garver Log Grades for Loblolly in Virginia 117
  Garver and Cuno Log Grades for Loblolly and Longleaf in S. Carolina 1935
  Franklin Tree Grades for Southern Pine 136
  Schlatter Log Grades for Southern Pine 142
  Log Grades for Shortleaf Pine in N. Arkansas 126
  Modified Crossett Grades for East Texas Pine Logs 118
  Southern Pine Association Log Grades 143
  Region 8 Log Grades for Loblolly and Shortleaf in S. Carolina 144
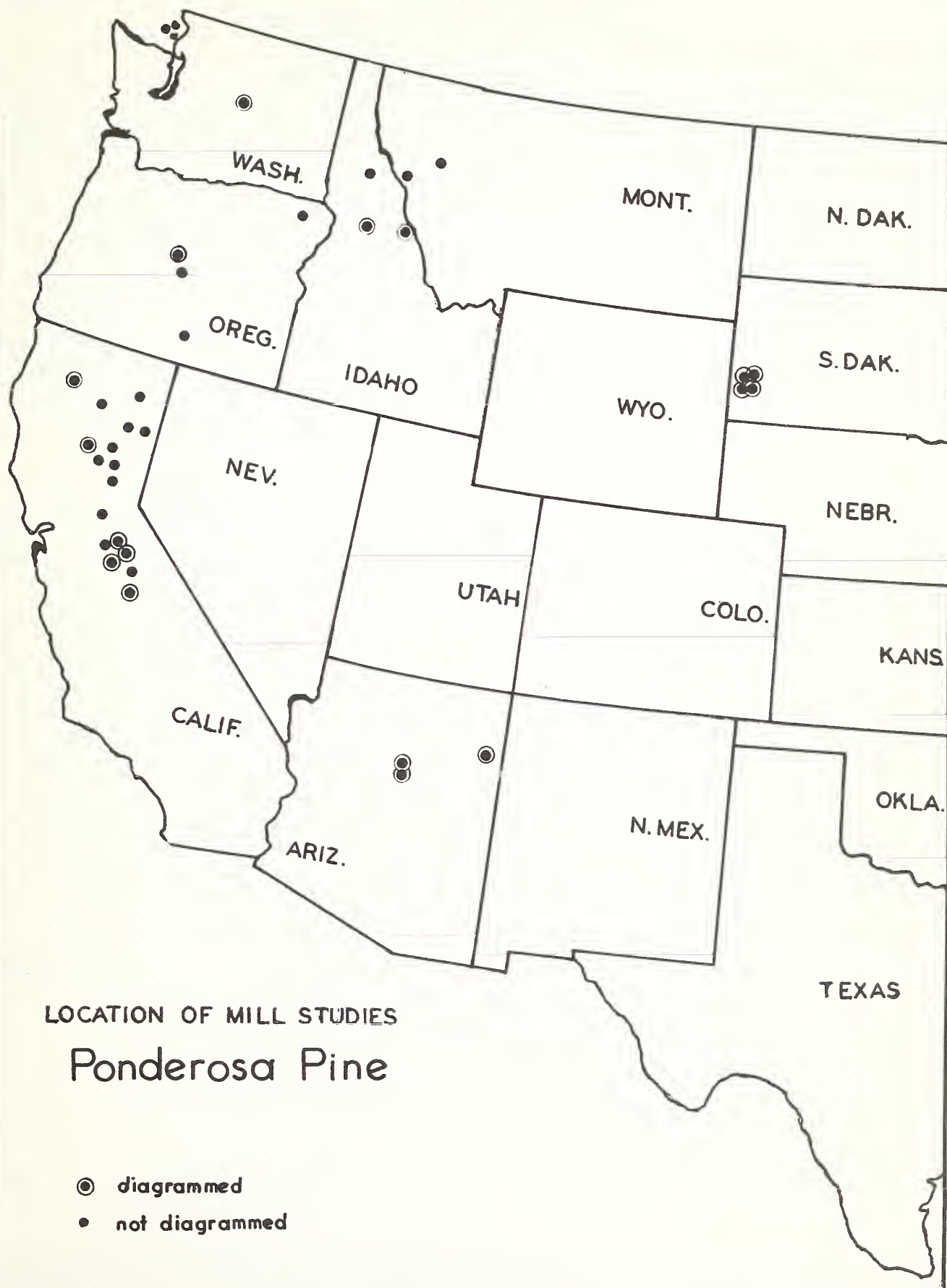
III. Hardwoods

1. Mixed Hardwoods

* Hardwood Log Grades for Standard Lumber (FPL factory lumber log
    grades) 30
  NETSA Hardwood Log Grades 92
  Purdue Log Grades 59
  Wallace's Hardwood Log Grades 93
  Northern Hardwood and Hemlock Assoc. Log Grades 65
  Otsego Coop. Hardwood Log Grades 68
  Pack Hardwood Tree Grades
  Texas Subgrades for FPL Grade 3 128
  TVA Use-Classes for Hardwood Logs 155
  Campbell's Tree Grades for Hardwoods 105a
  Garver and Miller Hardwood Log Grades of 1930 145
  Interim Sawlog Grades for Southern Hardwoods 152
  Modified FPL Grades for Maple and Alder in Oregon 218, 244
* Forest Service Hardwood Construction Lumber Use-Class 27
  TVA Tree Grades 110
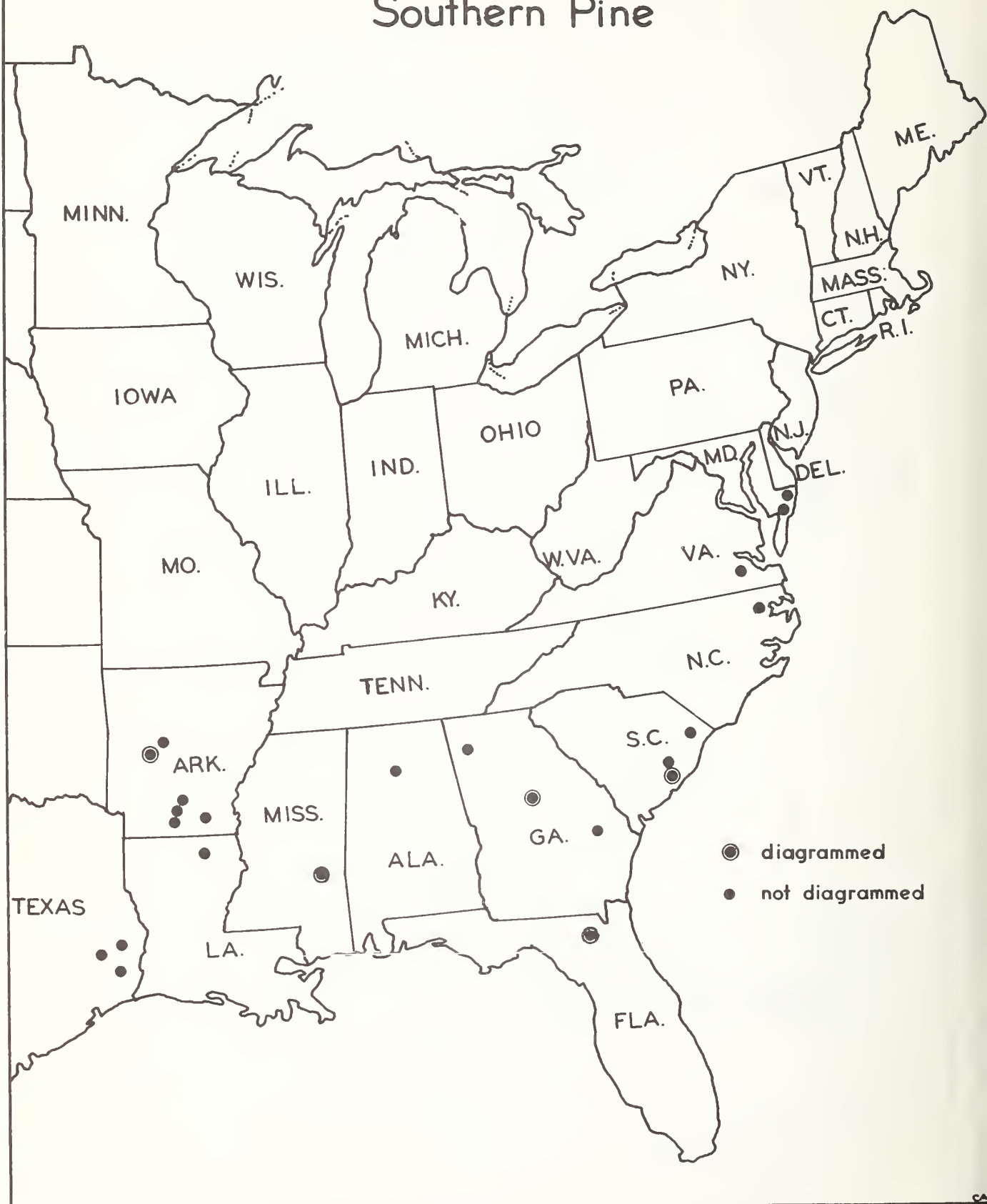
2. <u>Walnut</u>

       American Walnut Manu. Assoc. Grade Rules 1
       Tomlinson Co. Walnut Log Grades (TVA, King)
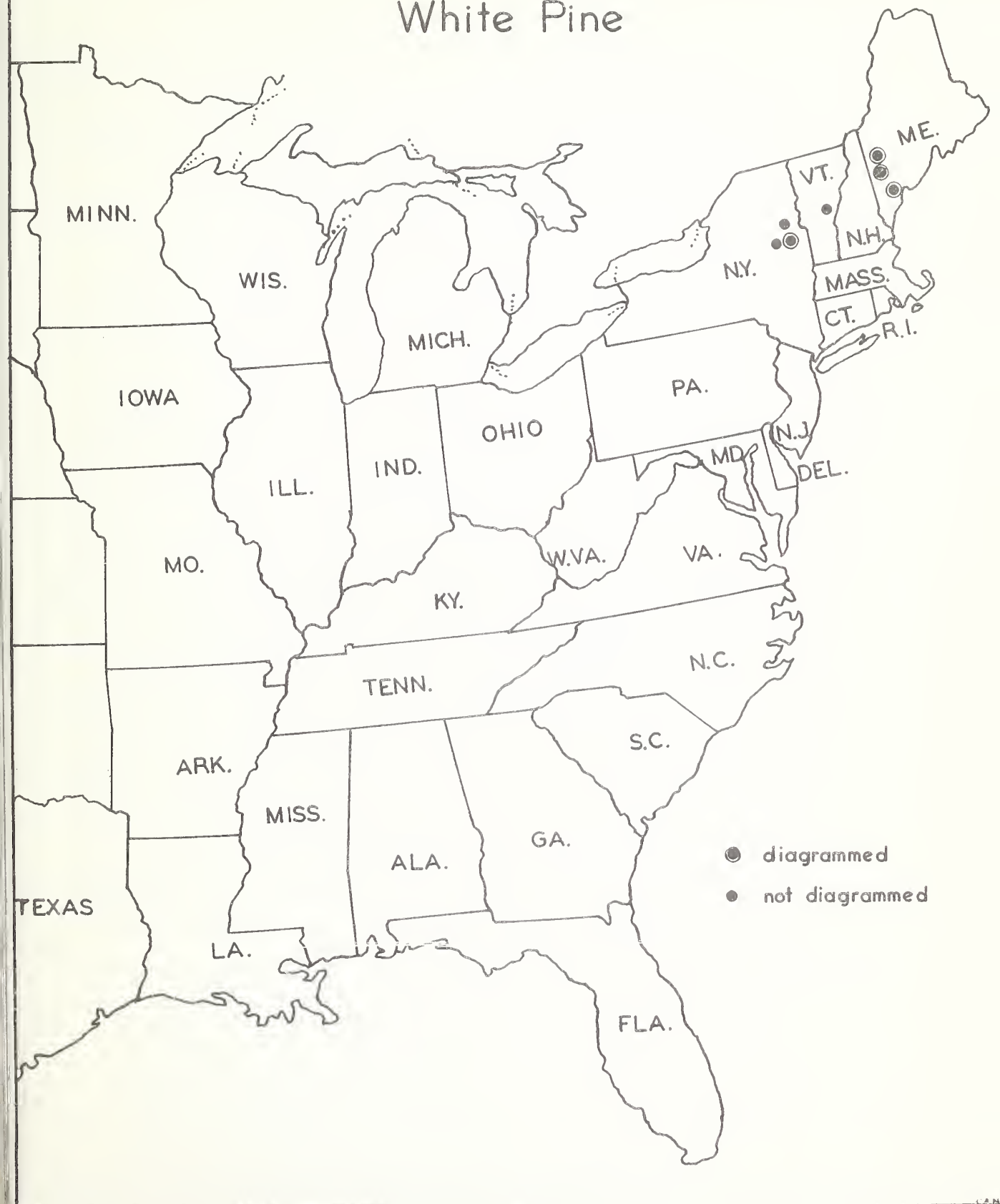   Stump's Walnut Log Grades (Lake States)

LOCATION OF MILL STUDIES
Ponderosa Pine

◎ diagrammed

• not diagrammed

LOCATION OF MILL STUDIES
Southern Pine

MINN.

WIS.

MICH.

NY.

VT.

ME.

N.H.

MASS.

CT.

R.I.

IOWA

ILL.

IND.

OHIO

PA.

N.J.

DEL.

MD.

MO.

KY.

W.VA.

VA.

TENN.

N.C.

ARK.

MISS.

ALA.

GA.

S.C.

TEXAS

LA.

FLA.

⊚ diagrammed

• not diagrammed

LOCATION OF MILL STUDIES

White Pine

diagrammed

not diagrammed

LOCATION OF MILL STUDIES
True Firs

● diagrammed
• not diagrammed

LOCATION OF MILL STUDIES
Hardwoods

diagrammed

not diagrammed

LOCATION OF MILL STUDIES

Douglas-fir

◉ diagrammed

● not diagrammed